Synthetic and Biomass Alternate Fueling in Aviation

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Hydrocarbon (HC) Addiction

- **Our planet is gripped by our addiction to hydrocarbon energy generation sources.**

  "*Addiction is a terrible thing. It consumes and controls us, makes us deny important truths and blinds us to the consequences of our actions.*"

  U.N. Secretary-General Ban Ki-Moon

- **"*We take pride in our clean, green identity as a nation and we are determined to take action to protect it. We appreciate that protecting the climate means behavior change by each and every one of us*."** Prime Minister Helen Clark, New Zealand

Civil Aviation Alternate Fueling Progress

- February 1, 2008, Airbus A380 3-hr **GTL fueled flight**
  - One of four Rolls-Royce Trent 900 engines fueled
  - Bristol to Toulouse to assess environmental impact
  - GTL (gas-to-liquid) fueling 50% Jet-A: 50% Blend
  - Goal regulatory 50:50 blend (2009): 100% GTL (2013)
- Feb. 24, 2008, Virgin Atlantic 747–400 40-min. **biojet fueled flight**
  - One of four GE CF6-80C2B5F turbofan engines
  - London to Amsterdam (320 km) altitude to (7.6 km)
  - 80% Jet-A: 20% processed babassu nut-coconut oils (Parente)
  - Ground tests to 60JetA:40biojet no discernable problems
- Continental – GE plan CFM56–7B biofuel 737 test (2009)
- CAAFI Civil Aviation Alternate Fuels Initiative
  Research, Emissions, Business, Regulatory Groups

Military Aviation Alternate Fueling Progress

- March 2008 B1B flew supersonic (50%JP8 : 50%SPK)
- **SPK** (Synthetic Paraffinic Kerosene) Standard
  MIL-DTL-83133F 11 April 2008
  Sperseeds MIL-DT-83133E 1 April 1999.
- SPK: CAAFI-ASTM modification for ASTM D1655.
- 17 Sept 2008 **50yr-old KC135 and F22 Raptor**
  Fueled 50:50 JP8-SPK

Heat Engine Exhaust Emissions (HC)-Fueled Systems
Health Hazards

- Particulate pollution : ***ultrafine particulates directly translocate to promote vascular system diseases.*** [Ultrafine: < 0.1 μm (< 100 nm)]

  Journal of America College of Caradiology (JACC) *.

  chronic respiratory diseases due to particulates are better known **

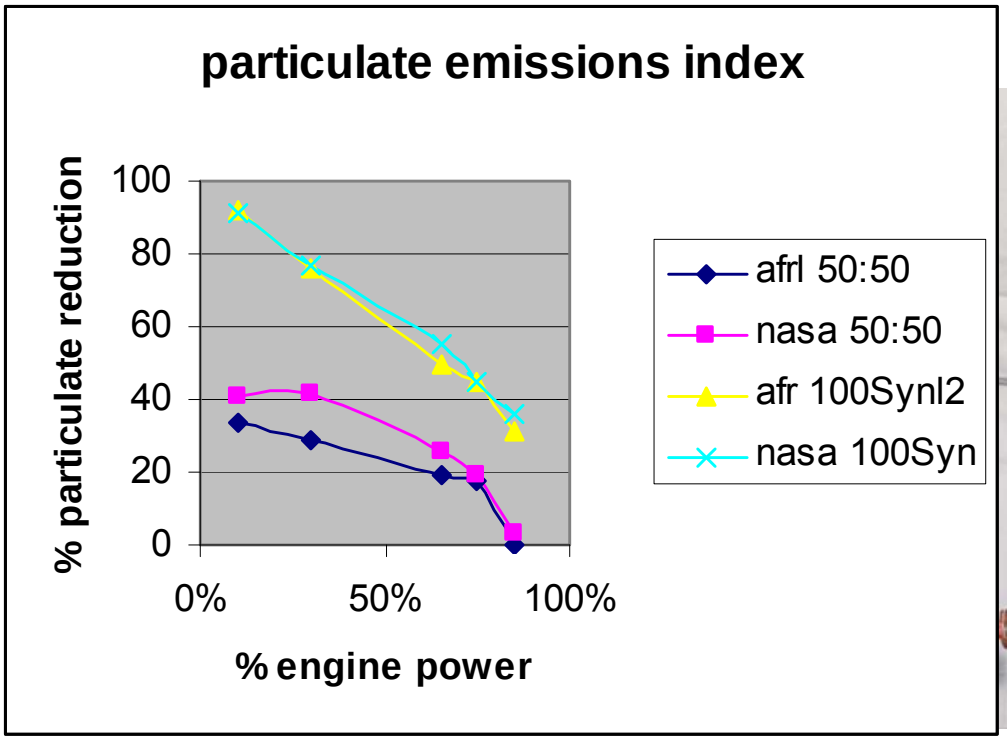
- Exhaust (tailpipe) emissions (20-140 nm) includes aircraft, mobility/stationary systems

•Simkhovich, B.Z, Kleinman, M.T., Kloner, R.A. (2008) Air Pollution and Cardiovascular Injury Epidemiology, Toxicology, and Mechanisms, Journal American College of Cardiology, 2008; 52:719-726, doi:10.1016/j.jacc.2008.05.029 (Published online 13 August 2008).
http://content.onlinejacc.org/cgi/content/short/52/9/719
** **Schwartz, J**. (1993) Particulate Air Pollution and Chronic Respiratory Disease, Environmental Research, 62, pp. 7-13

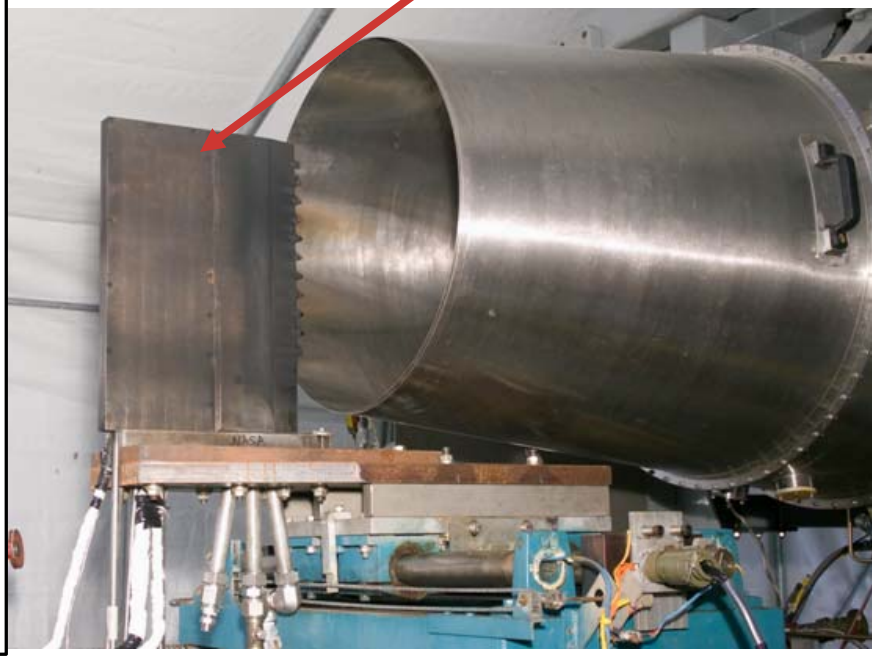
Civil-Military Engine Emissions Testing

- March 2008 PW-308 Engine Emissions FT- Jet A fuel test
- Fuels AFRL-FT, NASA-FT (Fischer-Tropsch), Jet A

Decreased particulate number with % power decrease for FT and Blends vs Jet A.



Exhaust Emissions Rake



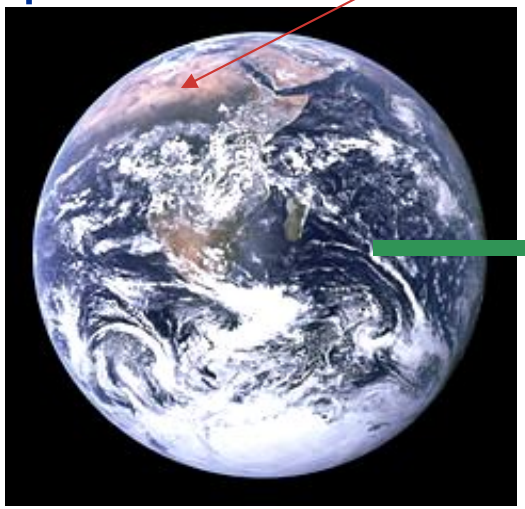
Aviation Ground Rules 2nd Generation Biomass Fueling

Criteria	KLM	Virgin Atlantic.	Boeing	Airbus	Air Transport Association
Water	No use of drinking water	Should not divert water away form food agriculture or drinking water	Does not require freshwater irrigation	Does not compete with water use for food crops or with drinking water	
Deforestation	No deforestation or forced relocation of people	Should not lead to deforestation	Does not lead to deforestation directly or indirectly	Does not compete with natural carbon sinks such as rainforest	
Soil	No soil degradation	Should apply sustainable agronomy principles (e.g., equivalent of FSC)	Apply sustainable practices	Apply sustainable practices	
Land and Food	Not compete with food or make use of arable land	Should not conflict with staple food crops	Does not compete with food	Does not compete with land use for food crops	
Emissions	No negative influence on biodiversity	Should have lower life cycle carbon emissions	Reduce CO2 (ie on order of -50% from current Jet A fuel)	Beneficial on a life cycle basis both in terms of global warming and local air quality	Voluntary Emissions Reduction
Supply			Supply sufficient quantity of lipids that could be converted to biojet fuel [11.5B US gal (2026)]	Aspirational goal to have up to 30% of commercial aviation fuel being biofuel in 2030. Set as a stretched goal to support scenarios discussion.	Reliable supply is critical; must be compatible with existing fueling infrastructure ; must meet regulatory and standards required by FAA
Economic Feasibility			Have some hope of becoming economic feasible (ie Processed biofuel costs no higher than today's Jet A fuel (<$4/gal)	To be demonstrated	Beneficial to both suppliers and purchasers
Feedstock			Assume the raw oil from multiple feedstocks could be equally easily converted into biojet fuel	Multiple feedstock will have to be used	Feedstock neutral; fuel must satisfy Safety and Quality, Environmental benefits, Reliability of supply, and be Economically feasible

Applying Abundant Resources and Halophyte (salt tolerant) Agriculture

Assumptions

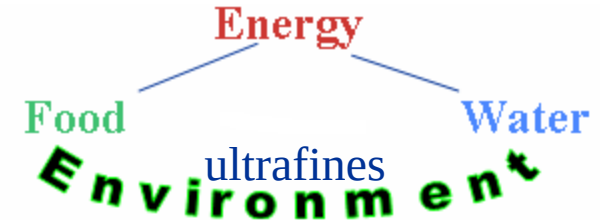
- **Sun**: solar incident radiation at 230 W/m2 daily
- **Seawater** (brackish water) irrigation
- **Arid Lands** : Total size of the Sahara Dessert (8.6×10^8 ha,13.6% of world arid or semi-arid lands)
- **Biomass**: Developed to its theoretical limits [10%]



Halophyte Agriculture Could Produce 7.126 kQ/yr 16× the World Q (2004)

Why Our Interests are Halophytes Algae Bacteria Weeds and Seeds

In a nut shell, here is the basis for our interest in Halophytes and derivatives



- 97% earth's water is seawater
- 80% (or more) plant nutrients are in seawater
- 43% earth's land is arid or semiarid
- 40% population growth in next 40-50 yrs.
- Global warming threatens methane hydrates in permafrost and ocean (CH4 release, 20X worse than CO2 as GHG)
- Ample solar energy available
  (to 16X total World Q in terms of biomass)
- Projected dearth: food supply, freshwater supply, energy supply
  current and projected environmental disasters + famines … by 2050 cities consume 50% world's freshwater…soil losses 5-10M ha-arable/yr …50% applied farm nutrients lost in runoff, leaching or erosion; worst is Gulf of Mexico
- Projected rise in ultrafine particulate health hazards impacts all living matter
- Inaction will lead to demise of humanity

This is an existential matter

So, Why Alternate Fueling ?

Ostensibly, foreign control of US

energy

food or

freshwater

supplies, implies the US would be quite limited

politically,

commercially and

militarily

in the future

What's the Problem Now ?

- We can make alternate Jet fuels
- CTL and GTL via FT processes
- Biomass fuels with conversion to Jet fuel

  Common crop oilseed [soybean, palm, coconut etc)

  Algae

  Bacteria

  Halophyte

  Wastes [municipal, livestock, forestry etc)

- So what's the problem ?
- Why aren't we in control of our fueling resources ?

The Problems

How to make these Fuel Resources

Secure

Sustainable

Economically viable

Sufficient Supply

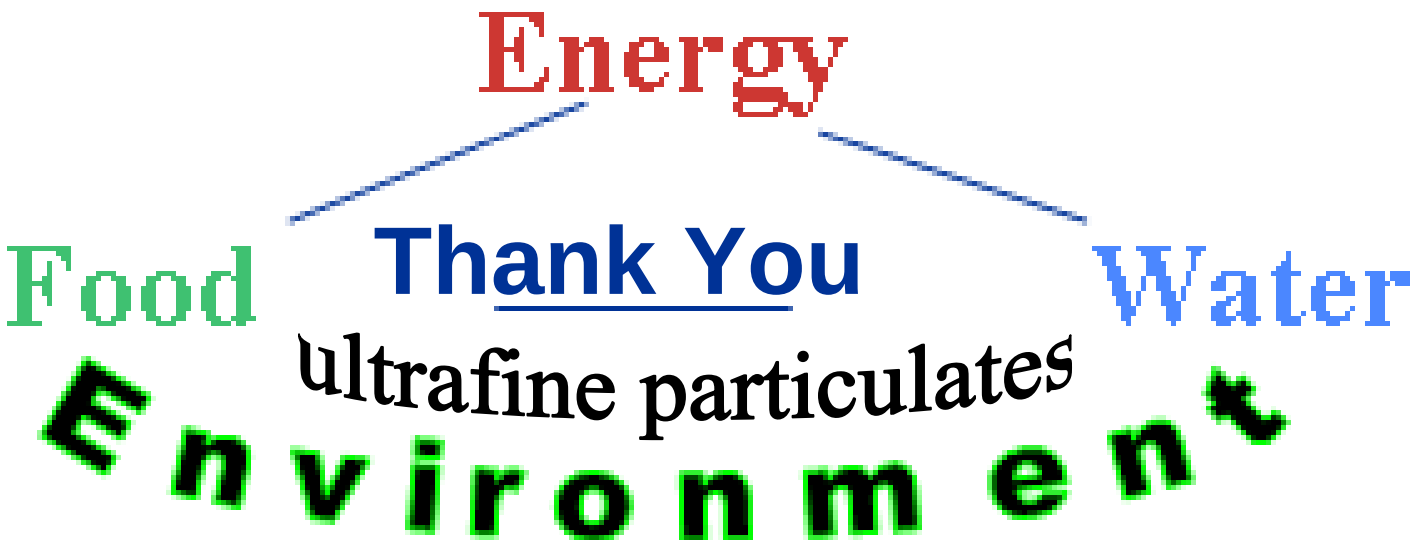
And Satisfy the Ground Rules

Conclusions

- **Must use Earth's most abundant natural resources**

  Biomass, Solar, Arid land (43%), Seawater (97%) with nutrients (80%) plus brackish waters and nutrients resolve environmental triangle of conflicts energy-food-freshwater and ultrafine particulate hazards

- **Requires Paradigm Shift - Develop and Use Solar * for energy; Biomass for aviation and hybrid-electric-compressed air mobility fueling with transition to hydrogen long term.** * PV-Thermal-Wind (thermal includes geothermal)


Energy
Thank You
Food
Water
ultrafine particulates
Environment